

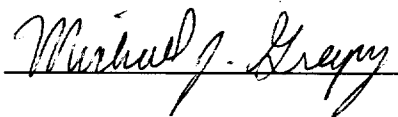
Identification of Resource Ownership by Scent  
Communication in White-Footed Mice (*Peromyscus leucopus*):  
A Test of Gosling's Scent Matching Theory

An Honors Thesis (HONRS 499)

by

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A handwritten signature in cursive script, reading "Michael J. Gregory", is written over a horizontal line.

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## NOTE TO THE READER

The following thesis is in the format of an article as it would be submitted to a scientific journal. The experiment described deals with scent mark communication between white-footed mice. This behavior is important in communication for other animals and once understood in one species some of the knowledge gained may be applied to others.

Large animals such as wolves and tigers are examples of species which use scent marking for communication among individuals. Both species also have a large impact on humans and their livestock as resources and space are getting more scarce. Since we cannot conduct experiments with such animals at Ball State University we use abundant native species.

Much can be learned about scent marking and social interactions even with a species as small in size as white-footed mice. As I am concluding this project I have learned that each species of mouse has extremely different behavioral characteristics. It would take many lifetimes to even attempt to understand the habits of just one species.

I chose to work with Dr. Michael Gregory because we share an interest in small mammal behavior and social interactions. In the past he has done research with hispid cotton rats and he is currently exploring scent communication in white footed mice. Working with Dr. Gregory has been very educational and valuable for me since I plan to continue my education in the field of wildlife ecology.

## ABSTRACT

This experiment explored the role of scent marking in communication of dominance and resource ownership in white-footed mice (*Peromyscus leucopus*). We tested the hypothesis that scent marks made by a resource owner familiarize an intruder with its scent for future recognition and thus decrease aggression levels. An intruder mouse was placed in an aquarium scent-marked by a resource owner. When the two were placed in a neutral arena for behavioral observation, less aggression occurred than between pairs of mice that were unfamiliar with each other.

## INTRODUCTION

Scent marking plays an important role in the social behavior of small mammals. Olfactory signaling with feces, urine, or secretions from scent glands may be the most important form of communication in some species (Johnson 1973, Thiessen and Rice 1976). Although much research has recently been done on this topic, not all of the messages communicated are adequately understood. Functions determined to be important in one or more species are: marking of territory boundaries (Thiessen and Rice 1976), orientation in the territory (Johnson 1973), male intraspecific competition (Gosling and McKay 1990), conspecific recognition, identification of members of the opposite sex (Mazdzer *et al.* 1976), trail marking, alarm signaling, group recognition, self reassurance, and threatening of intruders (Ralls 1971). Scent marking is very effective for species such as *Peromyscus* that are nocturnal and live

in relatively small territories with thick foliage where visual displays would not be very useful (Mykytowycz 1970).

Although scent marking does not prevent intruders from entering an occupied territory (Franklin 1980), the social dominance of the territory owner is conveyed to the intruder (Mykytowycz 1970). Gosling (1990) suggested that as an intruder enters a territory it learns the scent of the resource owner. By scent matching it then recognizes the owner upon meeting. If fighting over a defended area occurs, the owner has more to lose because of the time that it has invested in learning the location of resources within the territory (Maynard Smith and Parker 1976). The intruder is unlikely to defeat this defensive owner and therefore avoids fighting and the risk of injury (Parker 1974). Gosling and McKay (1990) showed that an intruder and an owner are slower to begin fighting when the intruder is placed on a substrate marked by the owner rather than another mouse.

This experiment tested if olfactory recognition of a resource owner functions to reduce the level of aggression. We exposed individual *Peromyscus leucopus* to resources marked by another animal and determined if an intruder exhibited reduced aggression when the intruder and owner were then placed together in a neutral arena.

## MATERIALS AND METHODS

White footed mice were trapped at Ball State University's Cooper Woods and Sixteen Acres in Muncie, Indiana approximately

weekly from September 1, 1992 to February 2, 1993. Sherman live traps baited with sunflower seeds were set in late afternoon and were retrieved the following morning. Lines of traps were set along the edges of and through the wood lots at an interval of 25 m. Polyester stuffing was provided for bedding when the overnight temperature was expected to drop below 0°C.

The mice were taken to the laboratory where they were tagged for identification, weighed, and sex and reproductive status were recorded. Mice were randomly assigned to pairs and were then randomly selected as belonging to experimental or control groups. Mice were not paired if their capture sites were located less than 150 m apart. Among the experimental pairs, one mouse was randomly designated as territory owner and the other as intruder. The territory owner and the trap that it was captured in were placed in the corner of a 30 gallon long aquarium at 1600 h on the day of capture. Sliced apple and sunflower seeds were placed in the diagonal corner. The animal was kept in the aquarium for 27 hours to allow it time for repeated use of the food and shelter resources and to deposit scent in the tank. After sunset the following day, the animal was then removed and the intruder was placed in the tank for 30 minutes.

After the scent acquaintance period, behavioral observations were made by placing both mice in a clean 20 gallon high aquarium for 5 minutes. A similar 5 minute observation trial was conducted for control pairs. The occurrence of the following behaviors was tallied for each mouse during the 5 minutes: aggressive posture, approach, attack, avoid, chase, close, defensive attack, flight,

following, groom self, and groom/sniff opponent (Table 1). All observations were conducted during the first three hours after sunset; illumination during the behavioral observations was provided by a 15 W incandescent red light bulb. The mice were returned to the site of capture the next day.

## RESULTS

The behavioral variables listed in table 1 were square root-transformed and then reduced to a single aggression index using principal-component analysis with varimax rotation (Table 2). This analysis reduces the number of variables in a data set by extracting factors that are correlated with one or more of the original variables. High positive factor correlations for attack and chase on factor 1 indicate that this is an aggression factor. Each pair's score on this factor was used as an index of the relative level of aggression that occurred during the pairing.

Analysis of variance (ANOVA) was used to determine if the level of aggression that occurred during the pairing depended on experimental treatment (control vs. experimental), reproductive season (April through October vs. November through March), and sex of the paired animals (male-male, male-female, or female-female). Aggression was related to experiment group ( $F = 9.61$ ,  $P = 0.003$ , Table 3). Pairs of mice used in the experimental group had lower scores on the aggression factor than mice that were unfamiliar with each others scent because they exhibited fewer of the behaviors correlated with factor 1 (Table 2). The overall level of aggression

between owner and intruder was therefore less than that between control (unfamiliar) mice. Aggression was not significantly associated with reproductive season ( $F = 2.84$ ,  $P = 0.096$ ) or the sex of the paired individuals ( $F = 1.15$ ,  $P = 0.321$ ). None of the interactions were significant.

Factor analysis was also used to calculate an aggression index for individual mice (Table 4). High positive factor correlations for attack and chase on factor 3 indicate that this is an aggression factor. Analysis of variance showed that the level of aggression of individual mice (their scores on factor 3) was not dependent on experimental use (scent marker or intruder) ( $F = 0.339$ ,  $P = 0.563$ , Table 5).

## DISCUSSION

The ability of individuals of many mammal species to defend necessary resources provides them with a mechanism to insure that they will have sufficient resources for survival and reproduction. Communication by scent marking appears to be an important component of resource defense (Hediger 1950, 1955) but the role of scent marking in establishing and maintaining territories has recently been questioned (Gosling 1990, Gosling and McKay 1990). Although it is well established that behavioral dominance and high aggression levels are associated with scent marking and that territory owners mark their territories, marking may not prevent intrusion by other individuals (Franklin 1980) and the role of scent communication in maintaining territories is unclear.

In order to maintain ownership of a territory, an individual must exhibit dominance behaviors (aggression) or else it will likely be evicted by a more dominant individual. Scent communication may facilitate communication of dominance but it seems unlikely that dominant territory holders produce a scent that can identify that animal as being dominant because "cheating" would be expected to evolve in subordinates and non-territory owners. Cheaters would be able to produce a scent that resembles that of a dominant animal and thus claims ownership of a territory without fighting. Gregory and Osborne (in preparation) showed that *Peromyscus leucopus* cannot identify dominance status based on odors unless the animals had previously encountered each other. Scent marks, therefore, may not be reliable indicators of the dominance status of the scent marker. Gosling (1990) suggested that scent marks allow individual recognition. An intruder would learn the scent of the owner as it traversed the territory and if it encountered a stranger, it would be able to determine if it were the territory holder. An intruder is unlikely to challenge an individual it identified as a territory holder because intruders rarely win these fights (Gosling and McKay 1990). Territory owners fight harder possibly because they have more to lose than the intruder has to gain. This imbalance is due to the considerable time and energy investment necessary to locate the resources on the territory. The territory owner has already made this investment but the intruder has not.

The lack of significance in the difference between the aggression scores of the individual scent markers and intruders must be explained by the fact that the mice were placed in a neutral



arena and neither mouse acted significantly more aggressive. If they had been placed on the owner's territory it is expected that the owner would be more aggressive than the intruder.

Gosling's (1990) speculation that scent marks function to familiarize an intruder with the owner's scent for future recognition was supported by this experiment. The pairs of mice that were used in the territory owner-intruder experimental group showed less aggression than the control mice (Table 3). The costs of defending a territory have been reduced if the scent mark can communicate ownership to an intruder. The intruder is less likely to challenge a mouse that defends an area so overall aggression should be lower. The energy saved by reduced fighting can be devoted to resource acquisition and mating.

This seems to be the first study of its kind recorded in the literature. The absence of similar studies indicates that there is a need for more experiments regarding the information communicated in scent marking. Future experiments should span longer periods of time so that trends throughout the entire year may be observed. This topic is important for further investigations of social interactions and dispersal of many species since the number of pieces of information communicated in a scent mark are unknown. This investigation indicated that dominance is one of the messages that can be learned by encountering a scent mark.

## AKNOWLEDGEMENTS

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Table 1.---*Definitions of Behavioral Variables Observed*

Variable	Description
Aggressive posture	standing on the hind limbs due to the presence of an opponent
Approach	movement to within 5 cm of an opponent
Attack	biting or lunging in an attempt to bite
Avoid	moving away from an opponent due to its presence
Chase	rapid pursuit of an opponent
Close	remaining closer than 5 cm for more than 5 seconds
Flight	rapid movement away from an opponent
Following	following an opponent as it walks
Groom self	grooming using the tongue and forelimbs
Groom self/ sniff opponent	grooming or sniffing an opponent

Table 2.---Rotated factor matrix of behavioral characteristics of Peromyscus leucopus pairs.

Variable	Factor		
	1	2	3
Aggressive posture	0.45547	0.05111	0.60491
Approach	0.39869	0.73603	0.01000
Attack	0.77745	0.02095	-0.02155
Avoid	0.66621	-0.08152	0.10054
Chase	0.65759	0.13725	0.50493
Close	-0.59875	0.46810	0.23127
Flight	0.82169	-0.05436	0.09221
Following	-0.11716	0.65028	-0.44242
Groom self	0.15894	0.22136	-0.72279
Groom/sniff opponent	-0.46885	0.71800	-0.07665

Table 3.---Analysis of Variance of Aggression Index with Experiment Group (control or experimental), Season (reproductive or nonreproductive), and Sex type of Mice.

SOURCE	DF	MEAN SQUARE	F	PROB.
MAIN EFFECTS	4	3.379	4.024	.005
Experiment group	1	8.073	9.614	.003
Season	1	2.389	2.844	.096
Sex type	2	0.969	1.154	.321
2-Way Interaction	5	0.366	0.436	.822
Exper. group-Season	1	0.971	1.156	.286
Exper. group-Sex type	2	0.036	0.043	.958
Season-Sex type	2	0.386	0.459	.634
3-Way Interaction	2	0.595	0.709	.495
Residual	78	0.840		
Total	89	0.922		

Table 4.---*Rotated factor matrix of behavioral characteristics of individual mice.*

Variable	Factor			
	1	2	3	4
Aggressive posture	0.61502	-0.07043	0.14768	-0.31200
Approach	-0.12088	0.68476	0.37903	0.10152
Attack	0.10136	-0.07742	0.78163	0.14574
Avoid	0.79759	-0.10395	0.01482	0.06381
Chase	-0.02973	0.08262	0.84951	-0.16990
Close	-0.32685	0.28847	-0.38058	-0.45341
Flight	0.82944	-0.13652	-0.03310	0.05530
Following	-0.08542	0.75804	-0.01607	0.17722
Groom self	-0.11184	0.18401	-0.04088	0.83304
Groom/sniff opponent	-0.14853	0.76389	-0.26576	-0.13595

Table 5.---Analysis of Variance of Aggression Index by Experimental Use (scent marker or intruder).

SOURCE	DF	MEAN SQUARE	F	PROB.
MAIN EFFECTS	1	0.119	0.339	.563
Residual	60	0.351		
Total	61	0.347		

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